

REPORT DOCUMENTATION PAGE				<i>Form Approved</i> <i>OMB No. 0704-0188</i>	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.					
1. REPORT DATE (DD-MM-YYYY) 9 May 2013		2. REPORT TYPE Consultative Letter		3. DATES COVERED (From – To) Jan 2013 – Apr 2013	
4. TITLE AND SUBTITLE Stewart Air National Guard Base, NY, C-5M Painting Refurbishment Assessment				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Capt Timothy Batten				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) USAF School of Aerospace Medicine Occupational and Environmental Health Dept Risk Analysis Division/OECM 2510 Fifth St. Wright-Patterson AFB, OH 45433-7913				8. PERFORMING ORGANIZATION REPORT NUMBER AFRL-SA-WP-CL-2013-0011	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSORING/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT Distribution A: Approved for public release; distribution is unlimited. Case Number: 88ABW-2013-2162, 9 May 2013					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT This consultative letter provides a health hazard assessment of painting chine coves on a C-5M with isocyanate paint.					
15. SUBJECT TERMS Occupational exposure, isocyanate paint, Iso-Chek, sampling, analysis, 95 th percentile, health risk assessment, Stewart ANGB					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 21	19a. NAME OF RESPONSIBLE PERSON Col Mark E. Smallwood
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER (include area code)



DEPARTMENT OF THE AIR FORCE
USAF SCHOOL OF AEROSPACE MEDICINE (AFMC)
WRIGHT-PATTERSON AFB OH

9 May 2013

MEMORANDUM FOR HQ AIR NATIONAL GUARD BUREAU/SGPB
ATTN: MAJOR STEIGERWALD
3501 FETCHET AVE
JOINT BASE ANDREWS, MD 20762

FROM: USAFSAM/OEC
2510 Fifth Street
Wright-Patterson AFB, OH 45433-7913

SUBJECT: Consultative Letter AFRL-SA-WP-CL-2013-0011, Stewart Air National Guard Base, NY, C-5M Painting Refurbishment Assessment

1. INTRODUCTION:

a. *Purpose:* A health risk assessment (HRA), including a comprehensive exposure assessment, was accomplished 8-10 January 2013. The U.S. Air Force School of Aerospace Medicine, Consultative Services Division (USAFSAM/OEC) assessed isocyanate exposures from spray painting operations during a C-5M refurbishment at Stewart Air National Guard Base, NY. This HRA was conducted in response to concerns that a lack of natural cross ventilation increases the exposure to isocyanates when the exterior hangar bay doors are kept closed during winter months. In July 2012, this facility was assessed with the facility's hangar bay doors open (see Consultative Letter AFRL-SA-WP-CL-2012-0063). Specifically, concerns focused on the adequacy of using the minimum required respiratory protection (RP) (e.g., air-purifying respirator [APR], with organic vapor cartridges and N-95 particulate prefilters, versus a loose-fitting, continuous-flow, supplied-air respirator [SAR]). The SAR provides a better assigned protection factor (APF) yet tethers the worker to an airline, negatively impacting freedom of movement and reducing the number of simultaneous spray painters from four to two. This consultative letter examines the health risk to isocyanate exposure regarding both types of RP.

b. *Health Hazard:* Isocyanates are a component of polyurethane paints. Exposure to isocyanates is irritating to the skin, mucous membranes, eyes, and respiratory tract. Sensitization-induced asthma is the most common negative health outcome associated with exposure to isocyanates. "After sensitization, any exposure, even to levels below the occupational exposure limit, can produce an asthmatic response that may be life threatening."¹

¹ **National Institute for Occupational Safety and Health.** *A Summary of Health Hazard Evaluations: Issues Related to Occupational Exposure to Isocyanates, 1989 to 2002.* Cincinnati, OH: NIOSH Publications Dissemination, January 2004. DHHS (NIOSH) Publication No. 2004-116.

c. *Survey Personnel:*

- (1) Industrial Hygiene Consultant, USAFSAM/OEC
- (2) Industrial Hygiene Consultant, USAFSAM/OEC
- (3) Industrial Hygiene Consultant, USAFSAM/OEC
- (4) Bioenvironmental Technician, 105 MDG/SGPB

d. *Personnel Contacted:*

- (1) NCOIC, Bioenvironmental Engineering, 105 MDG/SGPB
- (2) Aircraft Structural Maintenance Technician, 105 MXS/MXR
- (3) Aircraft Electrical & Environmental Systems Journeyman 105 MXS/MXR
- (4) Fuels Management Journeyman, 105 MXS/MXR

e. *Equipment:*

- (1) Bios DC-1 Dry Cal calibrator
- (2) SKC Airchek XR5000 sampling pumps. Product Code: 210-5003K5D (air sample pump)
- (3) SKC ISO-CHEK™, filter cassette. Product Code: 225-9022A (Iso-Chek™ sampler)
- (4) SKC Filter Cassette Holder. Product Code: 225-1 (cassette holder)

2. METHODOLOGY:

a. *Process Description:* The team from USAFSAM/OEC accomplished isocyanate air sampling from 8-10 January 2013 during the C-5M refurbishment process. The aircraft hangar, Building 101, can fully house one C-5M with the front and rear hangar bay doors fully closed. The largest use of isocyanate paint is during the painting of the chine coves (Figure 1). Chine coves are the voids adjacent to the cargo floor below the bench that runs the length of each side of the cargo bay. Chine coves are spray painted (Figure 2) with gloss white polyurethane paint. According to the safety data sheet for the Deft™ polyurethane paint, the gloss white poly resin hardener contains hexamethylene diisocyanate (HDI). Typically, between 6-8 liters of paint are applied by three active painters supported by one supervisor per shift. Only these four workers are on duty within the hangar during painting operations that normally occur between 1100-0600 hours. The number of shifts and duration required to paint the chine coves are largely determined by the degree of preparation performed by the prior day shifts and by the number of simultaneous spray painters. During this assessment three painters were able to complete the process over only two shifts, ranging from 135 to 180 minutes of actual paint application. Historically, one painter typically took four shifts to complete the same process. The entire aircraft refurbishment occurs over 3 weeks; therefore, the amount of time isocyanates are an exposure concern is relatively short. The only other painting operation that uses isocyanates is the escape hatch and galley refurbishment, and it takes less than one shift to complete. All other painting processes use water-based polyurethane. Regardless of which paint is used, all workers wear RP when entering the C-5M once painting has begun.

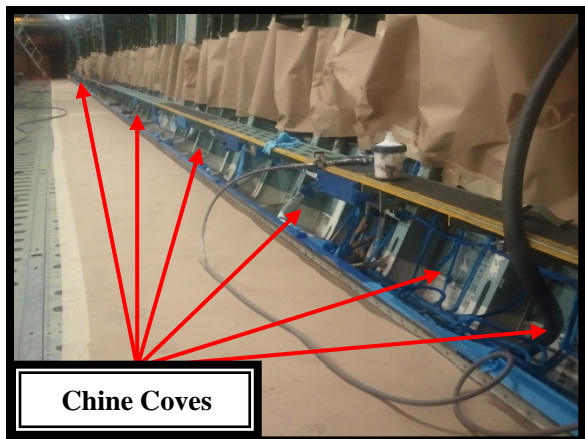


Figure 1: Chine coves prepped for painting



Figure 2: Chine coves being painted

b. *Sample Procedures:* Using Iso-Chek™ air samplers, 100% of the chine cove painting process was assessed. The Iso-Chek™ method is currently the only USAFSAM-recommended sampling protocol for quantifying both the monomer as well as the oligomer species of HDI². Laboratory analyses of the Iso-Chek™ samplers were performed by USAFSAM's analytical chemistry laboratory. The Iso-Chek™ samplers were clipped to the shoulder of the painters within the breathing zone. The cassettes were held in place with a cassette holder (oriented as shown in Figure 3). The flow rate for the Iso-Chek™ samplers was set at 1.0 liter per minute.



Figure 3: Iso-Chek™ sampler

c. *Health Hazard Controls:* During the assessment, all the exterior hangar doors were kept closed. However, a portable air handler was used (Figures 4a and 4b) to generate air movement from the open cargo area into the hangar. The air handler provides negligible control of the occupational health hazard. However, due to the limited nature of isocyanate painting processes, as discussed in the process description above, the installation of a permanent engineering control would be of limited cost benefit. Administratively, spray painting operations do not last the full 8-hour shift due to the preparation time and equipment breakdown/cleaning procedures at the

² **Batten, Timothy W.** *Base Level Guide for the Occupational Exposure to Isocyanates*. Wright-Patterson AFB, OH: U.S. Air Force School of Aerospace Medicine, 2012. AFRL-SA-WP-SR-2012-0003.

start and end of each shift, respectively. If the painting duration were significantly extended beyond what was administratively limited during this process (e.g. 135-180 minutes), then a new exposure assessment should be performed.

d. The focus of the exposure assessment centers on isocyanates, considered to be the most hazardous constituent in the chine cove painting process. The isocyanates are subdivided into two phases, the monomer and the oligomer phase. Six personal air samples (n=6; three workers/two shifts, each) were sampled for the full duration of each worker's chine cove painting process, using 15-minute partial period consecutive samples (as dictated by the Iso-Chek™ method). The results and recommendations in this letter are specific to the determinants of exposure (e.g. hangar doors closed, three simultaneous painters, 14 liters of paint applied, and painting durations of 135-180 minutes) at the time of the exposure assessment. IHSTAT³ was used to derive the statistical analysis and graphs for the monomer exposure and the oligomer exposure in the results section below.

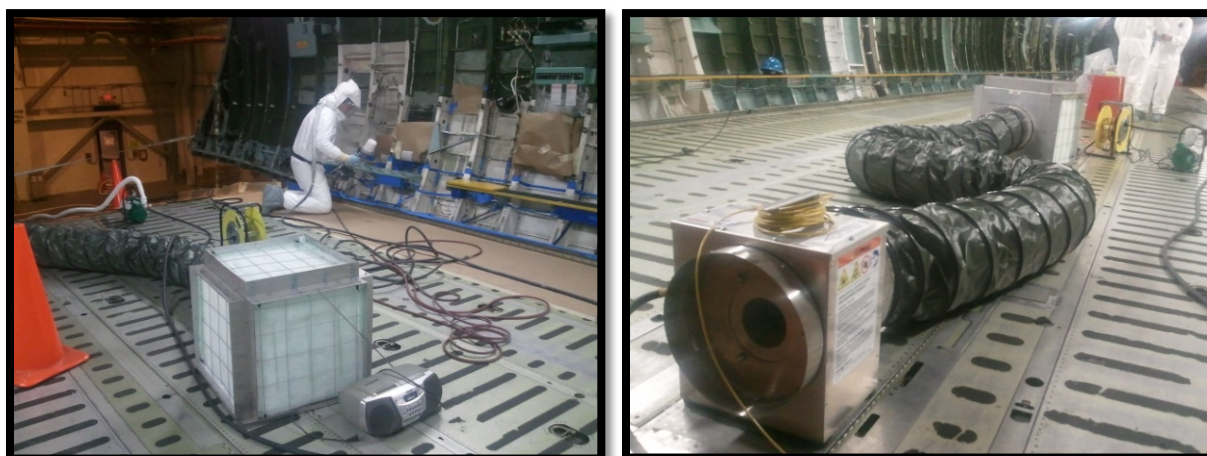


Figure 4a and 4b: Local exhaust for chine cove painting operations

3. RESULTS:

a. *HDI Monomer*: One of the six 8-hour time-weighted average exposures (8-h TWA) exceeded the occupational and environmental exposure limit (OEEL) of 0.034 mg/m³ presented in Table 1. Based on six out of six of the final samples being below the limit of detection, nonprocess exposure time was presumed zero for calculating the 8-h TWA, tabulated in Attachments 1 and 2. The American Industrial Hygiene Association recommends using “an occupational exposure assessment strategy directed at assessing all exposures for all workers on all days.”⁴ Fundamental to a comprehensive exposure assessment strategy is to compare the OEEL to the 95th percentile of the exposure profile. The 95th percentile is an estimate of the concentration above which about 5% of the exposures are expected to occur. Statistically, 5% of the exposures during the chine cove painting process can be expected to have a concentration

³ **Mulhausen, J.** IHSTAT Spreadsheet Program [CD]. In: Ignacio, J.S., Bullock, W.H., eds. *A Strategy for Assessing and Managing Occupational Exposures*, 3rd ed. Fairfax, VA: AIHA Press, 2006.

⁴ **Ignacio, J.S., Bullock, W.H., eds.** *A Strategy for Assessing and Managing Occupational Exposures*, 3rd ed. Fairfax, VA: American Industrial Hygiene Association, 2006.

greater than 0.097 mg/m³, or approximately three times the OEEL presented in Table 2. Conversely, the exceedance fraction is the estimated percentage of the exposure distribution that is calculated to be above the OEEL. The estimated percent of exposures above the OEEL for this distribution is 33.1% of the exposure profile. This can be interpreted that on any given day, any given worker has a 33.1% probability of exceeding the OEEL. USAFSAM recommends implementing control strategies for processes that have an exceedance fraction above 5%. An exposure profile (shown in Figure 5) graphically illustrates the magnitude and the variability of exposures for a similar exposure group, as depicted by the lognormal curve. Graphically, the exceedance fraction is represented by the area of the curve to the right of the OEEL.

b. *HDI Oligomer*: Three of the six 8-h TWA exposures exceeded the OEEL of 0.5 mg/m³ presented in Table 1. Based on five out of six of the final samples being below the limit of detection, nonprocess exposure time was presumed zero for calculating the 8-h TWA, tabulated in Attachments 1 and 2. The 95th percentile is calculated to be 3.7 mg/m³ and significantly exceeds the OEEL of 0.5 mg/m³ by more than seven times the OEEL. The exceedance fraction for this process is 32.8% of the OEEL, which likewise significantly exceeds 5% of the distribution. The exposure profile for the HDI oligomer's relationship between the 95th percentile and the OEEL is graphically illustrated in Figure 6. Note: The left side of the lognormal curve looks uncharacteristic due to the high geometric standard deviation of 5.3 for this exposure profile.

Table 1. Air Sampling Standards

Substance (Synonym)	8-h TWA Limit (mg/m ³)	Other Limits (mg/m ³)	Source Authority
HDI Monomer	0.034	---	ACGIH ^a
HDI Oligomer	0.5	1.0 ceiling	Oregon OSHA ^b

^aACGIH = American Conference of Industrial Hygienists

^bOregon OSHA = Oregon Occupational Safety and Health Administration

Table 2. Summary Statistics

Statistic	HDI Monomer	HDI Oligomer
OEEL	0.034 mg/m ³	0.5 mg/m ³
No. of Samples	6	6
Lognormal Distribution ^a	Yes	Yes
Geometric Mean	0.023 mg/m ³	0.238 mg/m ³
Geometric Standard Deviation ^b	2.383	5.3
Percent above OEEL ^c	33.1	32.8
95 th Percentile ^d	0.097 mg/m ³	3.7 mg/m ³

^aDetermined by the Shapiro and Wilk Test for normality.

^bA geometric standard deviation greater than 2 is considered highly variable.⁵

^cIdeally should be 5% or less.

^dIdeally should be less than the OEEL.

⁵ Leidel, Nelson A., Busch, Kenneth A. and Crouse, William E. *Exposure Measurement Action Level and Occupational Environmental Variability*. Cincinnati: National Institute for Occupational Safety and Health, 1975. NIOSH 76-131.

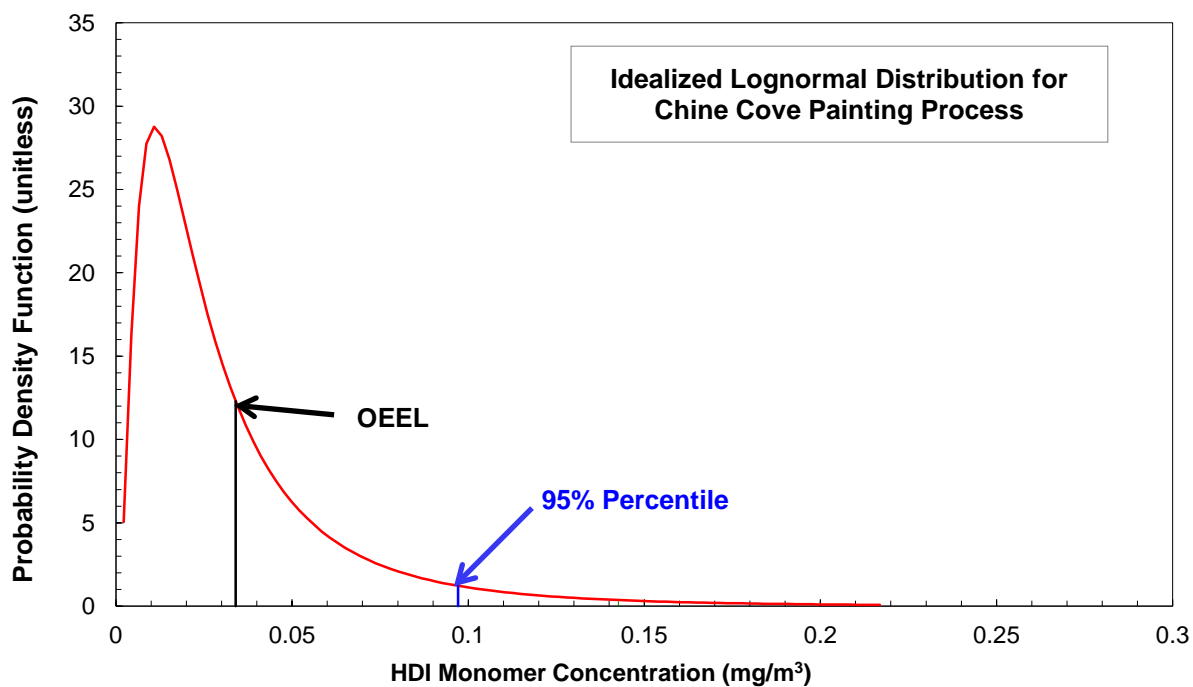


Figure 5: Exposure profile for HDI monomer

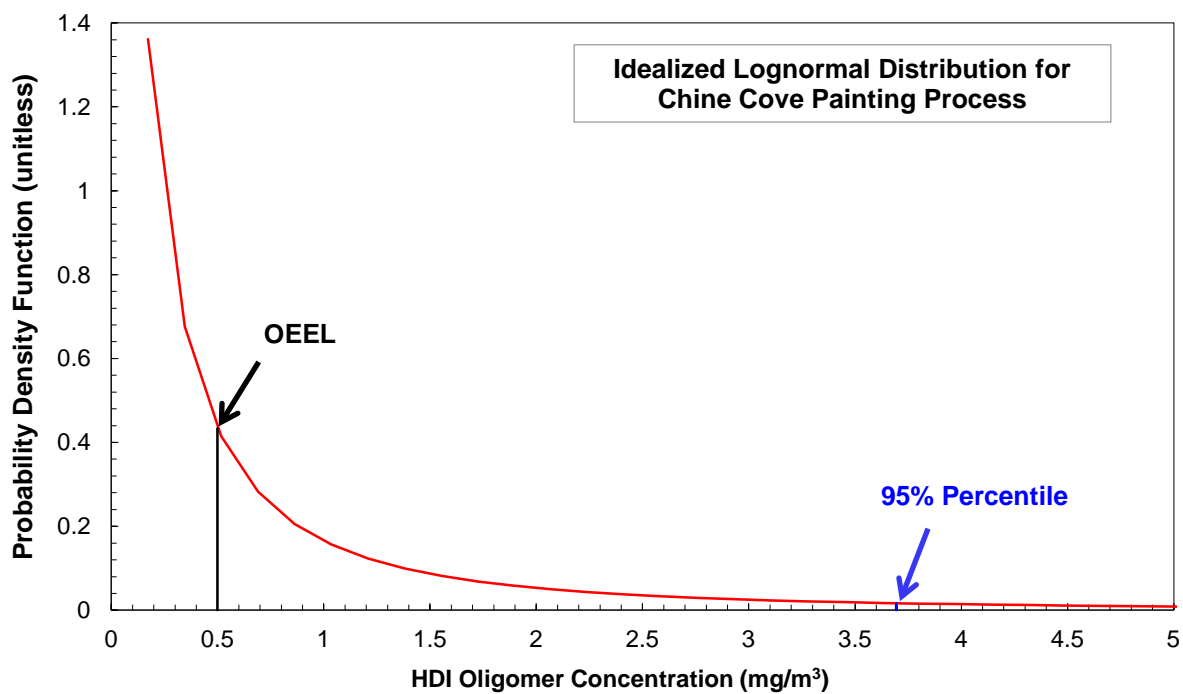


Figure 6: Exposure profile for HDI oligomer

c. A detailed summary of the sampling results by day and the sampling results by person for both monomer and oligomer phases of HDI can be found in Attachments 1 and 2, respectively. Due to the exposure characteristics of the isocyanate paint, USAFSAM recommends restricting access to the C-5M cargo bay to only authorized personnel wearing the minimum required RP. The minimum RP is a [full face piece]⁶ APR with organic vapor cartridges and N-95 particulate prefilters that provides an APF of 50 in accordance with Air Force Occupational Safety and Health Standard 48-137, *Respiratory Protection Program*, and 29 CFR 1910.134, *Respiratory Protection*. The APF of 50 is used to derive a maximum use concentration (MUC) as summarized in Table 3. The Occupational Safety and Health Administration (OSHA) defines the MUC as follows:

“Maximum use concentration means the maximum atmospheric concentration of a hazardous substance from which an employee can be expected to be protected when wearing a respirator, and is determined by the assigned protection factor of the respirator or class of respirators and the exposure limit of the hazardous substance. The MUC can be determined mathematically by multiplying the assigned protection factor specified for a respirator by the required OSHA permissible exposure limit, short-term exposure limit, or ceiling limit.”⁷

Table 3. Maximum Use Concentrations for APR

Substance (Synonym)	8-h TWA Limit (mg/m ³)	Ceiling Limit (mg/m ³)	RP (APF)	Calculated MUC		Exposure Concentration > MUC
				8-h TWA Limit (mg/m ³)	Ceiling Limit (mg/m ³)	
HDI Monomer	0.034 ^a	---	50	1.70	---	No
HDI Oligomer	0.50 ^b	1.0 ^b	50	25.0	50.0	No

^aSource authority: ACGIH

^bSource authority: Oregon OSHA Administration

4. DISCUSSION:

a. APRs are considered acceptable for isocyanate exposures provided the appropriate change-out schedule is in place.⁸ 29 CFR 1910.134(d)(3)(iii)(B)(2) states that, “...the employer implements a change schedule for canisters and cartridges that is based on objective information or data that will ensure that canisters and cartridges are changed before the end of their service life. The employer shall describe in the respirator program the information and data relied upon and the basis for the canister and cartridge change schedule and the basis for reliance on the data.” The service life of the filter cartridges is specific to each manufacturer. Currently, the 3MTM organic vapor cartridge with P100 particulate filter #60921 is used by the shop. According to 3MTM, under worst case conditions (90% relative humidity, 86° F, heavy work load, and an exposure concentration at the MUC of 1.7 mg/m³, as found in Table 3), the

⁶ Due to the eye hazard and not the respiratory hazard.

⁷ **Occupational Safety and Health Administration.** Personal Protective Equipment. Washington DC: U.S. Department of Labor. 29 CFR 1910.134(b).

⁸ **Kulick, Robert D.** *Local Emphasis Program - Isocyanates*. New York: U.S. Department of Labor - OSHA, 2011. OSHA Regional Notice, Directive Number 2012-12 (CPL 2), p. C-1.

estimated service life⁹ is **3,823 hours**. Under representative conditions (<65% relative humidity, 68° F, medium work load, and an exposure concentration of 0.123 mg/m³; the highest measured 8-h TWA in Table A1-2), the estimated service life is **118,799 hours**. 3M'sTM detailed reports of the cartridge service life calculations for both worst case and representative case can be found in Attachments 3 and 4, respectively. In either case, the service life is more than adequate to protect the worker throughout the duration of the chine cove process.

b. As of the date of this survey, painters used a Bullard CC20 loose-fitting hood (Figure 7). The shop has two Bullard EDP10 ambient air pumps to provide the painters' hoods with fresh air from outside the hangar (Figure 8). While exposures to HDI monomers and oligomers often exceeded exposure standards, the measured exposure concentration never exceeded the MUC calculated for an APR. The MUC for the Bullard CC20 loose-fitting hood in conjunction with the Bullard EDP10 air pump has an APR of 1000¹⁰, which provides an MUC 20 times greater than an APR.



Figure 7: Supplied air respiratory protection



Figure 8: Fresh air intake

5. RECOMMENDATIONS:

a. Based on the maximum use concentration calculations to isocyanates, painters must wear respiratory protection with an APF of 50 or greater.

⁹ **3M**. Service Life Calculation. *Select and Service Life*. [Online] [Cited: Mar 8, 2013] <http://www3.3m.com/SLSWeb/serviceLifeSolution.html>.

¹⁰ **E.D. Bullard Company**. *Bullard CC20 Series Hoods*. [Website] Cynthiana, KY: http://www.bullard.com/V3/products/respiratory/Supplied_Air/CC20/, Feb 2013.

b. Based on the ceiling level to isocyanate oligomers, all personnel entering the cargo bay of the C-5M during spray painting operations must wear RP with an APF of 50 or greater. Both the APR and the SAR respirators meet or exceed an APF of 50.

c. Change out APR filters, at a minimum weekly, after each chine cove painting process for each C-5M refurbishment. This assessment is limited to only the isocyanate exposure during the chine cove painting process and does not address the change-out schedule for other chemical hazards during the C-5M refurbishment.

d. Maintain a robust respiratory protection program to include the following: “fit testing, medical evaluations, proper use of respirators, training and information (including the need for a user seal check each time the respirator is donned), maintenance and care of respirators, program evaluation and recordkeeping” (see footnote 8, p. 7).

6. Thank you for affording USAFSAM/OEC the opportunity to assist you. If you have any additional questions or concerns, please contact Capt Timothy Batten at DSN 798-3296, or timothy.batten@wpafb.af.mil.



TIMOTHY W. BATTEN, Capt, USAF, BSC
Bioenvironmental Engineering Consultant

4 Attachments:

1. Summary Results
2. Detailed Sampling Results
3. Service Life Estimate – Worst Case
4. Service Life Estimate – Representative Case

Attachment 1 Summary Results

Table A1-1. Summary Results, Chine Cove Painting, 8 Jan 2013

Hazard	Sampling Duration (min)	Mass (µg)	Process TWA (mg/m ³)	8-h TWA OEEL (mg/m ³)	8-h TWA (mg/m ³)	Over 8-h Limit (Yes/No)
HDI Monomer	135	9.90	0.073	0.034	0.021	No
HDI Oligomer	135	95.4	0.71	0.5	0.20	No
HDI Monomer	150	12.05	0.083	0.034	0.026	No
HDI Oligomer	150	255.6	1.74	0.5	0.544	Yes
HDI Monomer	150	12.68	0.085	0.034	0.027	No
HDI Oligomer	150	321.4	2.16	0.5	0.67	Yes

Table A1-2. Summary Results, Chine Cove Painting, 10 Jan 2013

Hazard	Sampling Duration (min)	Mass (µg)	Process TWA (mg/m ³)	8-h TWA OEEL (mg/m ³)	8-h TWA (mg/m ³)	Over 8-h Limit (Yes/No)
HDI Monomer	180	11.10	0.062	0.034	0.023	No
HDI Oligomer	180	120.2	0.67	0.5	0.25	No
HDI Monomer	180	9.29	0.052	0.034	0.02	No
HDI Oligomer	180	6.71	0.04	0.5	0.01	No
HDI Monomer	180	59.27	0.329	0.034	0.123	Yes
HDI Oligomer	180	481.5	2.67	0.5	1.00	Yes

Attachment 2 Detailed Sampling Results

**Table A2-1. Iso-Chek™ HDI Monomer Results, Chine Cove Painting,
8 January 2013**

Sample Number	Sampling Duration (min)	Mass (µg)	Average Concentration (mg/m ³)	8-h TWA OEEL (mg/m ³)	Over Limit (Yes/No)
8EF4 ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8EF5	15	1.24	0.0827	0.034	Yes
8EF6 ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8EF7	15	2.29	0.153	0.034	Yes
8EF8 ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8EF9 ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8EFA ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8EFB	15	1.73	0.115	0.034	Yes
8EFC ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
Process Totals	135	9.90	0.073	0.034	Yes
8-h TWA	480	9.90	0.021	0.034	No

^aConcentration was below the laboratory's lower limit of detection (LOD).

**Table A2-2. Iso-Chek™ HDI Oligomer Results, Chine Cove Painting,
8 January 2013**

Sample Number	Sampling Duration (min)	Mass (µg)	Concentration (mg/m ³)	8-h TWA OEEL (mg/m ³)	Ceiling OEEL (mg/m ³)	Over Limit (Yes/No)
8EF4 ^a	15	<0.500 ^a	<0.0333 ^a	0.5	1.0	No
8EF5	15	38.8	2.59	0.5	1.0	Yes
8EF6 ^a	15	<0.500 ^a	<0.0333 ^a	0.5	1.0	No
8EF7	15	30.4	2.03	0.5	1.0	Yes
8EF8	15	2.34	0.156	0.5	1.0	No
8EF9 ^a	15	<0.500 ^a	<0.0333 ^a	0.5	1.0	No
8EFA	15	2.13	0.142	0.5	1.0	No
8EFB	15	19.7	1.31	0.5	1.0	Yes
8EFC ^a	15	<0.500 ^a	<0.0333 ^a	0.5	1.0	No
Process Totals	135	95.4	0.70	0.5	1.0	Yes
8-h TWA	480	95.4	0.20	0.5	1.0	No

^aConcentration was below the laboratory's lower LOD.

Table A2-3. Iso-Chek™ HDI Monomer Results, Chine Cove Painting, 8 January 2013

Sample Number	Sampling Duration (min)	Mass (µg)	Average Concentration (mg/m ³)	8-h TWA OEEL (mg/m ³)	Over Limit (Yes/No)
8EFD ^a	15	<0.774 ^a	<0.0527 ^a	0.034	No
8EFE	15	<0.774 ^a	<0.0527 ^a	0.034	No
8EFF ^a	15	1.26	0.0860	0.034	Yes
8EFG	15	1.05	0.0712	0.034	Yes
8EFH ^a	15	2.97	0.202	0.034	Yes
8EFI ^a	15	1.36	0.0925	0.034	Yes
8EFJ ^a	15	<0.774 ^a	<0.0527 ^a	0.034	No
8EFK	15	<0.774 ^a	<0.0527 ^a	0.034	No
8EFL	15	1.69	0.115	0.034	Yes
8EFM ^a	15	<0.774 ^a	<0.0527 ^a	0.034	No
Process Totals	150	12.05	0.08	0.034	Yes
8-h TWA	480	12.05	0.026	0.034	No

^aConcentration was below the laboratory's lower LOD.

Table A2-4. Iso-Chek™ HDI Oligomer Results, Chine Cove Painting, 8 January 2013

Sample Number	Sampling Duration (min)	Mass (µg)	Concentration (mg/m ³)	8-h TWA OEEL (mg/m ³)	Ceiling OEEL (mg/m ³)	Over Limit (Yes/No)
8EFD ^a	15	<0.500 ^a	<0.0340 ^a	0.5	1.0	No
8EFE	15	8.78	0.597	0.5	1.0	Yes
8EFF	15	40.1	2.73	0.5	1.0	Yes
8EFG	15	36.4	2.48	0.5	1.0	Yes
8EFH	15	52.4	3.56	0.5	1.0	Yes
8EFI	15	37.4	2.54	0.5	1.0	Yes
8EFJ	15	17.5	1.19	0.5	1.0	Yes
8EFK	15	15.5	1.06	0.5	1.0	Yes
8EFL	15	46.5	3.17	0.5	1.0	Yes
8EFM ^a	15	<0.500 ^a	<0.0340 ^a	0.5	1.0	No
Process Totals	150	255.6	1.74	0.5	1.0	Yes
8-h TWA	480	255.6	0.54	0.5	1.0	Yes

^aConcentration was below the laboratory's lower LOD.

Table A2-5. Iso-Chek™ HDI Monomer Results, Chine Cove Painting, 8 January 2013

Sample Number	Sampling Duration (min)	Mass (µg)	Average Concentration (mg/m ³)	8-h TWA OEEL (mg/m ³)	Over Limit (Yes/No)
8EFN ^a	15	<0.774 ^a	<0.0520 ^a	0.034	No
8EFO	15	1.29	0.0866	0.034	Yes
8EFP	15	0.931	0.0625	0.034	Yes
8EFQ	15	1.89	0.127	0.034	Yes
8EFR	15	1.63	0.109	0.034	Yes
8EFS ^a	15	<0.774 ^a	<0.0520 ^a	0.034	No
8EFT ^a	15	<0.774 ^a	<0.0520 ^a	0.034	No
8EFU	15	1.89	0.127	0.034	Yes
8EFV	15	1.95	0.131	0.034	Yes
8EFW ^a	15	<0.774 ^a	<0.0520 ^a	0.034	No
Process Totals	150	11.13	0.085	0.034	Yes
8-h TWA	480	11.13	0.027	0.034	No

^aConcentration was below the laboratory's lower LOD.

Table A2-6. Iso-Chek™ HDI Oligomer Results, Chine Cove Painting, 8 January 2013

Sample Number	Sampling Duration (min)	Mass (µg)	Concentration (mg/m ³)	8-h TWA OEEL (mg/m ³)	Ceiling OEEL (mg/m ³)	Over Limit (Yes/No)
8EFN	15	19.3	1.29	0.5	1.0	Yes
8EFO	15	35.1	2.36	0.5	1.0	Yes
8EFP	15	27.8	1.87	0.5	1.0	Yes
8EFQ	15	59.2	3.97	0.5	1.0	Yes
8EFR	15	43.2	2.90	0.5	1.0	Yes
8EFS	15	7.26	0.487	0.5	1.0	No
8EFT	15	11.0	0.739	0.5	1.0	Yes
8EFU	15	61.1	4.10	0.5	1.0	Yes
8EFV	15	57.2	3.84	0.5	1.0	Yes
8EFW ^a	15	<0.500 ^a	<0.0336 ^a	0.5	1.0	No
Process Totals	150	321.4	2.16	0.5	1.0	Yes
8-h TWA	480	321.4	0.67	0.5	1.0	Yes

^aConcentration was below the laboratory's lower LOD.

Table A2-7. Iso-Chek™ HDI Monomer Results, Chine Cove Painting, 10 January 2013

Sample Number	Sampling Duration (min)	Mass (µg)	Average Concentration (mg/m ³)	8-h TWA OEEL (mg/m ³)	Over Limit (Yes/No)
8F2K ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F2L ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F2M	15	0.944	0.0629	0.034	Yes
8F30 ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F31 ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F32 ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F33 ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F34 ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F3C	15	1.77	0.118	0.034	Yes
8F3I	15	1.42	0.0950	0.034	Yes
8F3J ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F3O ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
Process Totals	180	7.62	0.062	0.034	Yes
8-h TWA	480	11.13	0.023	0.034	No

^aConcentration was below the laboratory's lower LOD.

Table A2-8. Iso-Chek™ HDI Oligomer Results, Chine Cove Painting, 10 January 2013

Sample Number	Sampling Duration (min)	Mass (µg)	Concentration (mg/m ³)	8-h TWA OEEL (mg/m ³)	Ceiling OEEL (mg/m ³)	Over Limit (Yes/No)
8F2K ^a	15	<0.500 ^a	<0.0333 ^a	0.5	1.0	No
8F2L	15	10.1	0.676	0.5	1.0	Yes
8F2M	15	9.66	0.644	0.5	1.0	Yes
8F30 ^a	15	<0.500 ^a	<0.0333 ^a	0.5	1.0	No
8F31 ^a	15	<0.500 ^a	<0.0333 ^a	0.5	1.0	No
8F32 ^a	15	<0.500 ^a	<0.0333 ^a	0.5	1.0	No
8F33 ^a	15	<0.500 ^a	<0.0333 ^a	0.5	1.0	No
8F34 ^a	15	<0.500 ^a	<0.0333 ^a	0.5	1.0	No
8F3C	15	47.8	3.18	0.5	1.0	Yes
8F3I	15	34.1	2.28	0.5	1.0	Yes
8F3J	15	15.0	1.00	0.5	1.0	Yes
8F3O ^a	15	<0.500 ^a	<0.0333 ^a	0.5	1.0	No
Process Totals	150	120.2	0.67	0.5	1.0	Yes
8-h TWA	480	120.2	0.25	0.5	1.0	No

^aConcentration was below the laboratory's lower LOD.

Table A2-9. Iso-Chek™ HDI Monomer Results, Chine Cove Painting, 10 January 2013

Sample Number	Sampling Duration (min)	Mass (µg)	Average Concentration (mg/m ³)	8-h TWA OEEL (mg/m ³)	Over Limit (Yes/No)
8F2N ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F2O ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F2P ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F2Q ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F35 ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F36 ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F37 ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F38 ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F3A ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F3B ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F3K ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
8F3R ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
Process Totals	180	9.29	0.052	0.034	No
8-h TWA	480	9.29	0.019	0.034	No

^aConcentration was below the laboratory's lower LOD.

Table A2-10. Iso-Chek™ HDI Oligomer Results, Chine Cove Painting, 10 January 2013

Sample Number	Sampling Duration (min)	Mass (µg)	Concentration (mg/m ³)	8-h TWA OEEL (mg/m ³)	Ceiling OEEL (mg/m ³)	Over Limit (Yes/No)
8F2N	15	0.76	0.0507	0.5	1.0	No
8F2O	15	0.95	0.0633	0.5	1.0	No
8F2P ^a	15	<0.500	<0.0333	0.5	1.0	No
8F2Q ^a	15	<0.500	<0.0333	0.5	1.0	No
8F35 ^a	15	<0.500	<0.0333	0.5	1.0	No
8F36 ^a	15	<0.500	<0.0333	0.5	1.0	No
8F37 ^a	15	<0.500	<0.0333	0.5	1.0	No
8F38 ^a	15	<0.500	<0.0333	0.5	1.0	No
8F3A ^a	15	<0.500	<0.0333	0.5	1.0	No
8F3B ^a	15	<0.500	<0.0333	0.5	1.0	No
8F3K ^a	15	<0.500	<0.0333	0.5	1.0	No
8F3R ^a	15	<0.500	<0.0333	0.5	1.0	No
Process Totals	150	6.71	0.037	0.5	1.0	No
8-h TWA	480	6.71	0.014	0.5	1.0	No

^aConcentration was below the laboratory's lower LOD.

Table A2-11. Iso-Chek™ HDI Monomer Results, Chine Cove Painting, 10 January 2013

Sample Number	Sampling Duration (min)	Mass (µg)	Average Concentration (mg/m ³)	8-h TWA OEEL (mg/m ³)	Over Limit (Yes/No)
8F2R	15	1.54	0.102	0.034	Yes
8F2S	15	6.18	0.412	0.034	Yes
8F2T	15	4.96	0.331	0.034	Yes
8F2U	15	4.61	0.307	0.034	Yes
8F2V	15	3.86	0.258	0.034	Yes
8F2X	15	3.05	0.203	0.034	Yes
8F2Y	15	2.58	0.172	0.034	Yes
8F2Z	15	9.66	0.644	0.034	Yes
8F3D	15	7.4	0.493	0.034	Yes
8F3E	15	8.34	0.556	0.034	Yes
8F3L	15	6.32	0.421	0.034	Yes
8F3T ^a	15	<0.774 ^a	<0.0516 ^a	0.034	No
Process Totals	180	59.27	0.329	0.034	Yes
8-h TWA	480	59.27	0.123	0.034	Yes

^aConcentration was below the laboratory's lower LOD and was adjusted using the division by two method (LOD/2).

Table A2-12. Iso-Chek™ HDI Oligomer Results, Chine Cove Painting, 10 January 2013

Sample Number	Sampling Duration (min)	Mass (µg)	Concentration (mg/m ³)	8-h TWA OEEL (mg/m ³)	Ceiling OEEL (mg/m ³)	Over Limit (Yes/No)
8F2R	15	37.6	2.51	0.5	1.0	Yes
8F2S	15	40.6	2.70	0.5	1.0	Yes
8F2T	15	36.6	2.44	0.5	1.0	Yes
8F2U	15	39.5	2.63	0.5	1.0	Yes
8F2V	15	52.4	3.49	0.5	1.0	Yes
8F2X	15	62.2	4.14	0.5	1.0	Yes
8F2Y	15	48.5	3.23	0.5	1.0	Yes
8F2Z	15	41.2	2.75	0.5	1.0	Yes
8F3D	15	40.0	2.67	0.5	1.0	Yes
8F3E	15	48.6	3.24	0.5	1.0	Yes
8F3L	15	33.4	2.23	0.5	1.0	Yes
8F3T	15	0.900	0.0600	0.5	1.0	No
Process Totals	180	481.5	2.67	0.5	1.0	Yes
8-h TWA	480	481.5	1.00	0.5	1.0	Yes

^aConcentration was below the laboratory's lower LOD and was adjusted using the division by two method (LOD/2).

Attachment 3

Service Life Estimate – Worst Case

Report Details

Country: United States - English
Date: 03/08/13
3M Contact Information: OH&ESD Technical Service 1-800-243-4630
Comments:

Cartridge

Product Name 60921

Description NIOSH approved against certain organic vapors and particulates. Use with 3M(TM) Half and Full Facepieces 6000, 7000 and FF-400 Series with bayonet filter holders.

Image



WARNING:

These results are estimates only and must be used with caution. Change cartridge earlier if taste, smell or irritation from the contaminant is detected.

High relative humidity can dramatically reduce organic vapor chemical cartridge service life. A correction factor has been applied to the estimated organic vapor service life. Please see HELP for more information.

Your estimated service life is greater than 8 hours. Please see information on contaminant migration through the cartridge in the Help document. Establish cartridge change schedules that are easy for workers to remember (e.g., 1 day, 1 week, 1 month).

Solution

Estimated Service Life is 3823 Hours until breakthrough to 1/2 of the exposure limit (0.0025 ppm)

Service life calculation based on Hexamethylene diisocyanate at an Exposure = 1.7 mg/m³

Contaminants

Contaminant	CAS Number	Exposure	Exposure Limit	Molecular Weight	Odor Threshold
Hexamethylene diisocyanate	822-06-0	1.7 mg/m ³	0.005 ppm TLV	168.22	

Environment Questions

Relative Humidity 90%
Atmospheric Pressure 1.0
Temperature 86 Fahrenheit
Work Rate Heavy

Disclaimer

WARNING: This program expires on January 1, 2014.

This program is designed to provide a service life estimate only for the contaminants listed and under the conditions specified by the user. There are several limitations on the service life estimate. You must read all of the following warnings before using the 3M Service Life Software !

Failure to input proper information or misuse of the data may cause improper respirator use resulting in sickness or death. This estimate is only valid for the 3M respirator selected. If you use more than one type of 3M cartridge, you must run an estimate for those cartridges also. Do not use for 3M cartridges not listed. Do not use for other respirator manufacturers chemical cartridges. Due to the number of workplace variables, use these estimates with caution. Selecting [Help] provides further information for each screen.

If you have questions about the use or limitations of this software, contact 3M
OH&ESD Technical Service 1-800-243-4630

Attachment 4

Service Life Estimate – Representative Case

Report Details

Country: United States - English
Date: 03/08/13
3M Contact Information: OH&ESD Technical Service 1-800-243-4630
Comments:

Cartridge

Product Name 60921

Description NIOSH approved against certain organic vapors and particulates. Use with 3M(TM) Half and Full Facepieces 6000, 7000 and FF-400 Series with bayonet filter holders.

Image



WARNING:

These results are estimates only and must be used with caution. Change cartridge earlier if taste, smell or irritation from the contaminant is detected.

Your estimated service life is greater than 8 hours. Please see information on contaminant migration through the cartridge in the Help document. Establish cartridge change schedules that are easy for workers to remember (e.g., 1 day, 1 week, 1 month).

Solution

Estimated Service Life is 118799 Hours until breakthrough to 1/2 of the exposure limit (0.0025 ppm)

Service life calculation based on Hexamethylene diisocyanate at an Exposure = 0.123 mg/m³

Contaminants

Contaminant	CAS Number	Exposure	Exposure Limit	Molecular Weight	Odor Threshold
Hexamethylene diisocyanate	822-06-0	0.123 mg/m ³	0.005 ppm TLV	168.22	

Environment Questions

Relative Humidity <65%
Atmospheric Pressure 1.0
Temperature 68 Fahrenheit
Work Rate Medium

Disclaimer

WARNING: This program expires on January 1, 2014.

This program is designed to provide a service life estimate only for the contaminants listed and under the conditions specified by the user. There are several limitations on the service life estimate. You must read all of the following warnings before using the 3M Service Life Software !

Failure to input proper information or misuse of the data may cause improper respirator use resulting in sickness or death. This estimate is only valid for the 3M respirator selected. If you use more than one type of 3M cartridge, you must run an estimate for those cartridges also. Do not use for 3M cartridges not listed. Do not use for other respirator manufacturers chemical cartridges. Due to the number of workplace variables, use these estimates with caution. Selecting [Help] provides further information for each screen.

If you have questions about the use or limitations of this software, contact 3M
OH&ESD Technical Service 1-800-243-4630